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Hutchins, Susan G.

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Susan G. Hutchins[1*], William G. Kemple[1], John Poirier[2], Susan P. Hocevar[3], David L. Kleinman[1], and Michael G. Sovereign[1]

[1]Naval Postgraduate School, C4I Academic Group, 589 Dyer Road, Monterey, CA 93943
[2]Aptima, Inc. 1030 15th St, NW, Suite 400 Washington, DC 20005
[3]Naval Postgraduate School, Graduate School of Business and Public Policy (GSBPP), Monterey, CA 93943
Corresponding author: (831) 656-3768
shutchins@nps.navy.mil

Abstract

The need for rapid access to current, relevant, and accurate information is at an all-time premium — especially for military operations. Many new Information Technology (IT) Tools were introduced to facilitate these information-related interactions in the Global Wargame 2000, held at the Naval War College, in Newport, RI. A web-based architecture, called the Wargame Information Grid System (WIGS), and a collaborative planning and operational environment, the Information Work Space (IWS), provided an alternative means to communicate, collaborate, and share information among decisionmakers than is seen in today's current operational environments. In addition to WIGS and IWS, the following tools were provided to participants: Text Documents, the Knowledge Wall, Email, Text Chat, Voice, and Video Teleconferencing. Developing an understanding of the implications and effects of distributed gaming was a key goal of Global 2000 with one objective being to provide insight into future operations for a distributed, network-centric joint force. A sub-objective was to obtain empirical data as to the effectiveness of these new tools, and to identify user defined enhancements that would better meet the decisionmakers' requirements. In order to collect the data with which to assess user perceptions of the utility of IT Tools, an IT Tool Functionality Questionnaire was developed. This paper presents the results of analysis of data from 112 respondents' replies to the questionnaire designed to assess the utility of the IT Tools with respect to supporting the users accessing and sharing of information, decision-making, collaboration, and how they might be improved in future versions.

1. INTRODUCTION

The need for rapid access to current, relevant, and accurate information is at an all-time premium — especially for military operations. Moreover, the need for expeditious transformation of that information into "actionable" knowledge is increasingly recognized by the warfighter. This exchange and transformation of information to support the military decisionmaker was addressed

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in the Global 2000 Wargame held at the Naval War College (NWC) in Newport, RI. Global 2000 addressed the theme of Network Centric Operations as enabled via four "pillars:" Information/ Knowledge Assurance, Assured Access, Effects Based Operations, and Forward Sea Basing. Additionally, a unique organizational architecture was played reflecting an overlay of functional areas of responsibility across service components.

New Information Technology (IT) Tools, used as part of a networked, web-based collaborative system for command and control, were also introduced in the Global 2000 Wargame. These tools were provided to support planning and operational processes by providing an alternative means to communicate, collaborate, and share information among warfighters than seen in today's current operational environments. A key objective at Global was to obtain empirical data as to the effectiveness of these new tools, and to identify user defined enhancements that would better meet warfighter requirements.

While information access has always been critical to success in war, the concepts embodied in Network-Centric Operations (NCO) place an even greater emphasis on having rapid access to relevant and accurate information. Concepts such as Information and Knowledge Superiority, Knowledge Management, and Effects-Based Operations, are extremely important enablers of effective NCO. Changing organizational relationships anticipated for future warfare, expected tradeoffs in time and space, and the need for speed of effects with coordinated action, all point to the need for powerful, reliable, and capable IT tools to support the decision-maker. Further, these tools are expected to be critical elements of success for the warfighter who will be operating in a collapsed battlespace, working toward the goals of achieving shared awareness, information/ decision superiority, unity of effort, and the ability to respond autonomously.

2. BACKGROUND

The organizational structure played in Global was a hybrid of service components crossed with warfare functional areas. Thirteen functional areas (Ground Control/ Close Air Support, Operational Maneuver From The Sea, Theater Missile Defense, Air Defense, Deep Strike/ Interdiction, Sea Control, Special Operations Forces, Rear Area Security, Intelligence, Sensing, and Reconnaissance, Fires Coordination, Effects, Information Warfare, and Logistics) were played. Responsibilities for their execution were passed to service component commanders: NAVFOR (Navy), MARFOR (Marine Corps), AFFOR (Air Force), ARFOR (Army), and JSOTF (Special Operations). These commanders functioned in dual roles as both service component commanders and warfare functional area commanders responsible to the Commander, Joint Task Force (CJTF). Participants were distributed locally at the NWC in rooms functioning as "player cells" representing operational entities, with some 250 computers.

2.1 Distributed Game Environment

A geographically distributed environment was provided enabling both Commander in Chief (CINC) play aboard USS CORONADO in San Diego, CA, and assessment of collaboration between other remote locations using the Global 2000 collaborative tool suite. Several new technologies were introduced to facilitate interactions in this distributed environment, including a web-based architecture, called the Wargame Information Grid System (WIGS), and a collaborative planning and operational environment, the Information WorkSpace (IWS). Additionally, emergent technologies such as the Knowledge Wall and CAESAR II, were introduced as collaboration, decision support, and course of action analysis tools The need for

extensive collaboration and coordination across functional areas and components to accomplish the mission was recognized as key to the success of this organizational design.

2.2 GLOBAL Wargame 2000 Objectives

During Global Wargame 2000, several aspects of the game were examined and evaluated by various teams who focused on knowledge management, IT Tool utilization, organizational design and adaptation, and effects based operations. The implications and effects of distributed gaming were also key features of Global 2000 with one objective being to provide insight into future operations for a distributed, network-centric joint force. Additionally, a sub-objective for the game was to explore the use of tools to enable the participants to self-synchronize their planning, decisions and actions, and to facilitate clarification of the roles and responsibilities for participants at each of the distributed sites. The introduction of these new IT tools, a unique way of organizing the forces, and new processes to be employed for conducting business made for an ambitious agenda and provided a complex data collection environment.

2.3 IT Tool Use Assessment

It is important to note that several of these IT tools were implemented for the first time during Global Wargame 2000. Moreover, several of these tools were included *for the express purpose* of testing their *potential* utility and gathering data on how they might be enhanced. Therefore, a questionnaire was developed to help obtain information that would be useful to the developers of the various tools by collating feedback from a sizable sample of the participants. Most of the tools provided were in various stages of development — with some still in the conceptual design phase. Thus, feedback from the game participants has been taken as constructive feedback to support developing improved tools to enable Network-Centric Operations.

2.4 Additional Analyses

This paper represents the results of analysis of the data gathered at Global Wargame 2000 on IT tool use, participants' responses regarding tool limitations, and suggested improvements. Additional analyses are required to fully interpret all the data. One important analysis, would be to assess the participants' responses to the questions on the IT tools while taking into account the various locations and "jobs" of the people who rated the tools, and from the perspective of the intended audience of each of the tools. It is anticipated that this analysis may affect the ratings of the tools, as are presented in this analysis. It is recognized that participants who did not have access to some tools, e.g., Video Teleconferencing (VTC), yet rated them on the questionnaire, may have rated their usefulness as "low" because they did not use that particular tool. This further reflects a requirement to objectively assess tool usefulness in terms of subjective utility assessments by participants as to the relative value of the tools' ability to meet the different priorities and mission objectives of players at varying positions within the organization. With respect to some tools, such as VTC, many participants in the component cells either did not have access or perceive a direct need for its use.

3. IT TOOL FUNCTIONALITY QUESTIONNAIRE

In order to collect the data with which to assess user perceptions of the utility of IT Tools, an IT Tool Functionality Questionnaire was developed by the Adaptive Architectures for Command and Control[1] (A2C2) research team. The IT Tool Functionality Questionnaire was a modified

[1] The A2C2 research team is comprised of researchers from Naval Postgraduate School (NPS), industry (primarily

version of the questionnaire that was administered at GLOBAL Wargame 1999. This questionnaire was developed to support an assessment of the utility of the IT Tools with respect to supporting the users' access to and sharing of information, decision-making, collaboration, and how the tools might be improved in future versions. The questionnaire was developed to obtain feedback on the functionality and limitations of the tools provided for GLOBAL Wargame 2000. The questionnaire consisted of six items that asked the participant to address the questions listed below. This paper presents the results of analysis of the responses to these items.

1. Which tools were most helpful and how were the tools helpful?
2. How did the tools impact decision-making?
3. Rank the order of the tools (on a scale from 1 – 8) in terms of their usefulness and provide comments on usefulness (1=lowest utility; 8=highest utility).
4. What were the negative aspects of the tools?
5. Rate the tools (on a scale from 1 – 8) in terms of what features you would like to see in the design of a collaborative system?
6. How effective was the pre-game training?

3.1 Tools Included in IT Tool Questionnaire

The following section provides a brief description of each of the eight tools that were included in the questionnaire.[2]

3.1.1. Text Documents. Text Documents were a collection of documents located within the web-based gaming architecture. These documents included material such as the Battle Plan, Commander's Intent, Rules of Engagement (ROE), and many others.

3.1.2. Knowledge Wall. The Knowledge Wall (KW) was designed to provide senior decision-makers with a common view of game information and to support a novel model of collaboration (that is, asynchronous collaboration) for the senior CJTF staff. In addition, by virtue of it being installed for both the CJTF and the Commander, in Chief (CINC), it provided a means of collaborating for the CJTF and CINC echelons, as a secondary function.

The KW was developed and included in Global 2000 at the request of COMTHIRDFLT and COMCARGRU ONE, who also suggested adaptations for use during the Global 2000 Wargame to explore the implications of Network-Centric Warfare for C4I. The KW comprises ten 21-inch CRTs, and two large-screen displays. The displays operate as a single, integrated digital desktop. Due to its early stage of development, the functionality of the KW was limited in GLOBAL 2000. Conceptually, the KW may be viewed as a dynamic status board. The small, peripheral displays were intended to provide summary information for each of 13 functional areas that were identified through knowledge engineering with US Navy COMTHIRDFLT, COMCARGRU ONE, and COMCARGRU THREE staff. (These functional areas correspond to the 13 areas that were played at Global.) Each summary display is formatted consistently with a variety of tools dedicated to different operational requirements.[3]

Aptima), and several universities. The A2C2 research program is a multidisciplinary effort to establish a body of knowledge in current and future joint command and control and develop and test theories of adaptive architectures.

[2] Several other tools were used during GLOBAL Wargame 2000, however, many of these other tools were developed for smaller sub-sets of the participants and thus were not included in the questionnaire.

[3] Knowledge Wall Brochure, Space and Naval Warfare Systems Center, San Diego, (SSD).

3.1.3 Email. Email was a standard commercial-off-the-shelf email system.

3.1.4 WIGS. The War-Gaming Information Grid System (WIGS) was designed to be the central source for shared awareness of the game play. WIGS was developed to be the authoritative data source for game information. A Global Wargame 2000 interactive homepage was developed to provide players with a means of planning, communicating, and promulgating orders. Promulgation of this information via the web site was intended to facilitate changes to the Common Operational Picture and also provide for review of players' decisions, strategy, and direction both during game play and afterwards.[4] The objective for this web site was to: (1) post information for all players, (2) provide access to analytic tools and to an underlying database of reference and briefing materials, (3) facilitate posting and exchange of documents, as well as (4) provide links to additional web sites, hosted within the Wargaming Center, NWC, in order to provide additional information related to game play.

3.1.5 IWS. The Information WorkSpace (IWS) is a collaborative planning and operational environment designed to be used within and among the functional and service components played in Global 2000. IWS was designed to facilitate collaboration on those portions of the game where planning was required to produce the recurring products that were required as well as the products produced in response to the game play.[5] The capabilities afforded by IWS were expected to be tailored by the users to their specific requirements. Some functions provided by IWS include real-time text chat and voice, both conducted over the internet.

3.1.6 Text chat. Text chat is a tool within the Information WorkSpace (IWS), and provides a form of interactive communication where more than one person can join the chat session to collaborate. All occupants within a virtual "room" (within the IWS tool) can view and respond interactively to an initiator's message.

3.1.7 Voice. Voice is also a tool within the IWS where a person can talk with everyone who is in the same "room."

3.1.8 VTC. Video teleconferencing was a standard commercial-off-the-shelf system.

4. METHOD

The IT Tool Functionality Questionnaire was distributed to participants in all functional areas and component cells at the completion of the last phase of Global Wargame 2000. Ninety-three questionnaires were returned and the data from these questionnaires forms the basis for the results included in this paper. Additional information, in terms of feedback provided by Naval Postgraduate School observers aboard the USS Coronado, and information collected using an earlier version of the questionnaire[6], is also included in the results and recommendations.

A brief analysis of a portion of the data was completed during GLOBAL 2000 and was provided to the Knowledge Management Group. At that time a request was made for further analysis of the data to look for differences among the groups that participated in the wargame and to

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4 GLOBAL 2000: The Distributed Gaming Environment. CDR. Mike Waite, Modeling and Simulation, Naval War College, Newport, RI.

5 From GLOBAL 2000 Business Rules, Naval War College, Newport, RI.

6 Questions in the earlier version were formatted differently. This original version was modified during Global Wargame 2000; observers at San Diego did not receive this modified version, thus the quantitative data was not included in this analysis. Qualitative data from the CINC have been included in this paper.

summarize the participants' comments that were included as part of their ratings of the IT tools. The questionnaires were grouped according to components and cells and formed the following eight groups for the analysis:

GROUP	Number in Group
CJTF	34
AFFOR	7
ARFOR	13
MARFOR	8
NAVFOR	16
Reachback	7
Others *	8

*(Participants in the "Others" group included CINC, Anchor Desk, NCA, JOC, 2 JSOTF, and 2 JTF J4.)

5. RESULTS

This section presents the results of questionnaire items #3, 4, and 5 for each tool. These items asked about the benefits associated with each tool, the limitations, and what features were desired in a future collaboration tool. Data from the questionnaire for all three items will be discussed under each tool. Responses to survey items 1 and 2 are not reported here for the sake of brevity.

5.1 Factors Influencing Ratings

Ratings of the tools were influenced by seven factors: (1) the position of the participant within the organization, in addition to the tool's (2) functionality (i.e., the perceived utility of the features offered); (3) usability (i.e., how easy they were to use); (4) reliability (how well the tool functioned during Global 2000); (5) implementation (who the tool was designed to support, that is, certain tools were developed to support a specific subset of the participants); (6) connectivity (who had access to the tool — this is a critical variable, as many participants did not always have connectivity to all the tools); and (7) the user's level of proficiency in using the tool.

5.2 Differences in Information Needs

Participants' operating in different locations in the overall organization (i.e., different functional areas, different warfare areas, and at different levels in the hierarchy) will have different information needs. These differences include the specific types of information required (e.g., weather is critical to certain functional areas, and less critical to others), the level of detail desired, and so on, and these varying needs will impact the user's ratings of the tools. For example, at the highest levels of the organization, the emphasis will usually be on an integrated high-level picture of the situation, whereas at the lower levels the decisionmaker will often want to focus in on the specifics of a local event or the particular functional area for which that node in the organization has responsibility. These varying emphases, based on differences in information needs, appear to have affected how different participants rated the usefulness of the tools, what they viewed as limitations, and what features they would like to see in a future collaboration tool.

An additional factor that affected ratings of the tools was technical difficulties encountered during game play that precluded access to the full functionality of some tools. In thee cases,

participants may, in some cases, have had higher expectations regarding tool capabilities and utility than were met. It appears that participants' ratings of the various tools' utility were influenced by how relevant the tools were to the people making the ratings — rather than simply the overall utility of the tool. It should also be noted that user familiarity with tool functionality, capabilities, and operating procedures varied dramatically among players/users. Many participants expressed a need for additional training that would have enabled the users to more effectively employ the tools.

5.4 Overall Usefulness of IT Tools

Figure 1 shows the results of the respondents' overall ratings when asked to rank order the tools on a scale from least useful (1) to most useful (8) in terms of the benefits to organizational effectiveness and their usefulness in accomplishing the mission and assigned tasks. The mean rankings of the tools fell into four groups. Email and WIGS received the highest rankings with means of 6.9, and 6.5, respectively, on an eight-point scale. These two tools were ranked notably higher than the rest of the tools. Text Documents, Knowledge Wall, and Text Chat received the next highest ratings. These three tools all were rated about equally with mean rankings of 4.8, 4.5, and 4.6, respectively, on an eight-point scale. Voice and IWS formed the third group, in terms of perceived usefulness, and received rankings of 3.6, and 3.4, respectively. VTC was ranked the lowest with a mean ranking of 2.3.

Rank ordering of tools in terms of the benefits to organizational effectiveness and their usefulness in accomplishing the mission and assigned tasks. (1=least useful; 8=most useful)

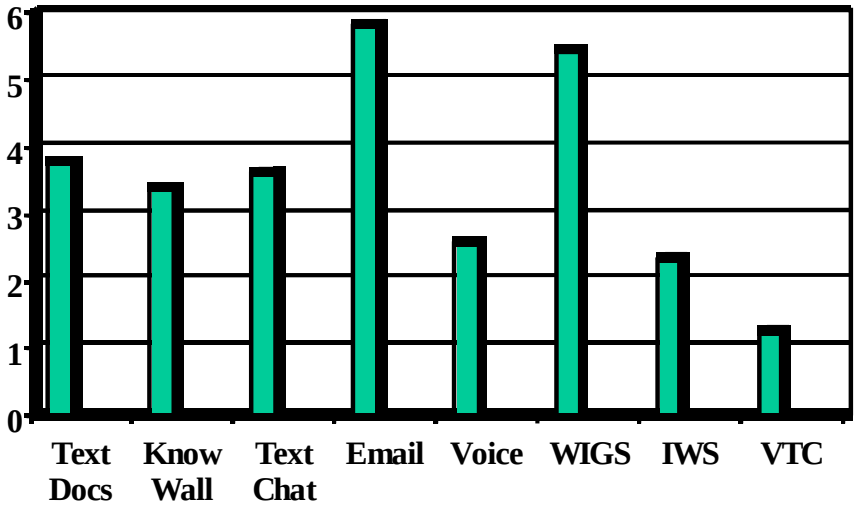

Figure 1. Overall Mean Ratings of IT Tools for Usefulness.

The following paragraphs provide an interpretation of the rankings of the tools based on the comments participants listed on the questionnaires. All comments regarding the tools for items 3, 4, and 5, which asked about the benefits, negative aspects, and features they would like to see in a future collaborative tool, respectively, are listed in appendices in the technical report (Hutchins, Poirier, Hocevar, Kemple, Sovereign, Kleinman, Entin, & Rizzuto, 2000). As might be expected,

participants' comments were not necessarily consistent. The tools will be discussed in the order in which they were ranked, with the highest rated tool discussed first.

5.1.2 Email. All groups rated Email very high; mean ratings ranged from 6.4 to 7.9 on an eight-point scale. Table 2 presents the ratings, by each of the groups, for all the tools assessed on this questionnaire. Respondents indicated that familiarity, reliability, utility, and usability were all strong factors contributing to this tool receiving the highest ranking of all the tools.

	CJTF	AFFOR	ARFOR	MARFOR	NAVFOR	Reach-back	Other	Overall Mean
Email	6.6	7.9	7.3	7.5	6.4	7.4	6.4	**6.9**
WIGS	6.8	6.8	6.4	6.1	6.3	5.6	6.6	**6.5**
Text Docs	4.7	4.4	4.8	6.0	4.3	6.0	4.5	**4.8**
Text Chat	4.8	4.4	3.2	4.5	5.5	4.2	4.5	**4.6**
Know Wall	4.9	3.7	3.5	3.5	4.2	5.6	5.9	**4.5**
Voice	3.1	4.0	4.1	3.2	3.7	5.4	3.4	**3.6**
IWS	3.5	2.5	3.5	2.1	4.1	2.2	3.2	**3.4**
VTC	2.2	1.7	3.3	1.6	2.4	2.0	2.1	**2.3**

Table 2. Mean rankings of IT tools by group.

However, the fact that Email was rated highest needs to be interpreted in light of the context in which the tools were used and rated, based on anticipated and unanticipated technical and objective game dynamics. Throughout Global 2000, Email was consistently and universally available whereas IWS was not available to all players, thus, Email may have appeared to participants as the most reliable form of allowing tasking between cell and component commanders. In some cases, Email was the only means of communication for participants in addition to direct personal interaction, (i.e., walking into another cell/room to directly communicate with another player).

5.1.2.1 Benefits of Email. Email received the highest rating for usefulness because it: was always available and was thus the most reliable way to communicate between all cells; provided everything but video; was fast, easy and familiar; provided a great paper trail; and was possible to pass documents as attachments Another factor that may account for Email receiving the highest rating is that users had a high degree of familiarity with Email whereas many participants had far less familiarity and experience with the other tools. This high level of familiarity with Email minimized the "costs" incur-red in using Email versus the newer, less familiar tools. These costs may include cognitive workload in recalling tool functions, capabilities, and operating procedures; additional communication and interaction requirements to align situation awareness regarding tool products, and the additional time associated with performing tasks due to lack of proficiency in tool utilization.

5.1.2.2 Limitations of Email. The following salient comments provide an indication of what the participants viewed as the drawbacks associated with Email. Since Email was not collaborative, one does not know when it gets read; it has limited distribution compared to web posting; when Email was miss-sent or was time late it was not considered; important email can be ignored

because it tends to be point-to-point; some statements of plans by components were posted as fact without higher approval; and it was sometimes difficult to decide what was information versus opinion.

5.1.3 WIGS. WIGS received the second highest ranking, thus indicating that people found it to be a very useful tool. Participants were fairly consistent in their ratings of WIGS. The mean ratings, broken out by the seven groups, ranged from 5.6 to 6.8 on an eight-point ranking scale.

5.1.3.1 Benefits of WIGS. Features offered by WIGS that participants considered to be useful are that it provided: an effective way to share information; rapidly available information, and a tool that was easy to use; access to many information areas, including the Knowledge Wall; good navigation and good links; a good "base" to go to, to get situation assessment and lots of information; the ability to see what higher headquarters sees for information; and having all information on one page was advantageous.

5.1.3.2 Usability Limitations of WIGS. Usability issues were the main concerns expressed as indicated by the following feedback concerning WIGS: there were system capacity limitations, it was "mouse click" intensive, it was hard to know when plans had been updated, users needed to be in two places simultaneously, and there were time latency issues. Additional usability issues included: the lack of an automatic refresh for posted updates; it is cumbersome to move between environments; it is time intensive and hard to find the really good stuff (e.g., Intel could be hidden in many places); there was no single site to find out how the war was going; the user had to sign up and boot to update battle plans; and the user had to search to find changes versus the system presenting information.

5.1.3.3 Suggested Improvements for WIGS. Suggested improvements for WIGS included recommendations related to both usability and functionality. Functionality issues included the need to present the common operational picture, a means for the user to know when something has changed, e.g., continuous situation summaries; and provide a single site to track the war. Usability issues suggested include providing: a better navigation system; a central, common hub (this is critical); a more compact system that requires less "clicks;" and a way to made it easier to move between environments.

5.1.4 Text Documents. Text documents received the third highest ranking in terms of usefulness of the eight tools included on the questionnaire. Participants' rankings of Text Documents ranged from 4.3 to 6.0, on an eight-point scale (see Table 2).

5.1.4.1 Benefits of Text Documents. Comments listed by participants regarding the benefits of Text Documents include that it provided baseline data, and archived, public access information and permitted linking data to graphics.

5.1.4.2 Limitations of Text Documents. Usability and functionality issues were also the main concern regarding Text Documents. Usability issues included that the user had to "pull" information versus the system "pushing" information to the user, and it was difficult to find and track what was needed. Issues related to functionality were that there was too much information to read, and it was difficult to keep track of changes regarding documents posted, e.g., ROE were difficult to track. Although participants felt the documents provided good background material, there was too much content to absorb and retain while engaging in the scenario. Other stated

limitations of Text Documents include that there was no real-time update, it was not always current, and it needs to include explicit Commander's Intent.

5.1.4.3 Suggested Improvements for Text Documents. Improvements that participants would like to see for a future Text Documents tool include usability and functionality issues: having fewer documents to read during the wargame, keeping the documents updated, and then making it easier to track changes would improve the functionality, or usefulness, of this tool. Participants felt that there was not enough time during Global 2000 to read all the documents and that some should be provided to participants to be read prior to the exercise as a "read-ahead' package. Additional comments regarding improvements for Text Documents include the need for: a Joint on-line campaign plan developed before the wargame starts, an automatic save capability; and a ROE timestamp to facilitate tracking changes.

5.1.5 Text Chat. Text Chat was considered to be useful for intra-cell, analyst-to-analyst collaboration and "stove-piped" activities, but was viewed as being less useful for horizontal/vertical (i.e., cross-cell) collaboration. This perceived limited usefulness for cross-cell collaboration is reflected in the participants' ratings of the usefulness of Text Chat, which ranged from 3.2 to 5.5, on an eight-point scale.

5.1.5.1 Benefits of Text Chat. Text Chat was viewed as affording benefits for collaborating and planning. Participants noted that it: provided an excellent backup to email when rapid response was essential; should be the only tool utilized to develop executive plans; was good for real-time collaborating; and it offered another form of email but better and faster

5.1.5.2 Limitations of Text Chat. Salient comments regarding what the participants viewed as limitations to Text Chat pertain to the functionality of Text Chat. Text Chat was: limited to only one area or "room," thus, not it did not support inter-cell collaboration (note that this contrasts with what some perceived as benefits offered by Text Chat); not archived, so previous messages blurred together; difficult to keep thoughts between the various participants organized; cumbersome with more than a few participants; sufficient for stove-piped activities, but not supportive for coordination between participants in different cells; and labor intensive, such that some users required a dedicated operator.

5.1.5.3 Suggested Improvements. Participants recommended that the following changes be incorporated to Text Chat: Include ALCON (all concerned) in the net; provide the capability to keep a home chat open; provide an automatic archive capability that can be exported to limit redundant key strokes; make more areas accessible in the same room; add a "History join" feature where the user can see conversation before joining; and develop a protocol for use.

5.1.6 Knowledge Wall. The Knowledge Wall was viewed an excellent concept that needed more maturity. Participants' rankings of the Knowledge Wall ranged from 3.5 to 5.9 (see Table 2). The KW received its highest ratings from participants who were functioning higher up in the organization, that is "Others," Reachback, and CJTF. This may reflect that the intended audience/user for the KW was the CJTF. Participants in the component cells rated it lower, most likely because they had to provide information to the KW (and the information flow tended to be one-way, i.e., to the senior echelons).

5.1.6.1 Benefits of the Knowledge Wall. Selected comments made by participants regarding the usefulness of the Knowledge Wall include the following: if properly tasked/managed, it is an excellent tool to keep the commander informed; it provided a good tool to see a change in situation assessment and permitted rapid information distribution; provided good information as long as it was kept up to date; provided a common source of data; once we had a clear idea of content it was great; and it provided rapid display and access to a lot of knowledge.

5.1.6.2 Limitations of the Knowledge Wall. The following comments provide an overview of what the participants viewed as limitations to the Knowledge Wall. The main limitations were that it was labor- and time-intensive to support, the lack of interactiveness and auto-update, too much "drilling" to get situation awareness, and the one-way usefulness, i.e., to the CJTF. Additional comments regarding limitations include that it: was a "data sponge" as it required constant input; required a person dedicated full-time for input; provided infrequent Situation Awareness summaries; needed a summary for WIGS; did not provide an integrated, fused picture; did not have well-defined business rules such that different cells used varying criteria; and because all pages could not be displayed at once, no unified picture was presented.

5.1.6.3 Suggested Improvements for the Knowledge Wall. Improvements listed as desired for the Knowledge Wall include: the need to update the information more frequently, it was too rigid—need to know where to find the information vs. information being there, it was a menu more than providing specific information. Additional comments regarding improvements include the need for: updating the information more frequently; better manipulation tools; providing a standard for red, yellow, green to facilitate interpretation; displaying an integrated, fused picture; smart "pull" from an integrated workstation; design around Joint Doctrine approved functional areas; and providing updated alerts, with prioritization.

5.1.7 Voice. Many participants indicated they did not use Voice due to problems with the system's availability and/or reliability. As with comments received on the other tools, there was some contradictory feedback across players, such as "Essential for direction" and "Could be very helpful," which contrasts with "Email and Text Chat served the purpose well." Participants' rankings of Voice ranged from 3.1 to 5.4, indicating they felt it was moderately useful.

5.1.7.1 Benefits of Voice. Of those who did use this tool within IWS, the benefits perceived to be provided by Voice included: it was the fastest way to pass time-critical information and was a good to clear up questions when an issue was not clear.

5.1.7.2 Limitations of Voice. The following comments concerning usability issues provide an overview of what the participants viewed as limitations to Voice. There was no record of a conversation, thus it can be misinterpreted; it was difficult finding the person you desire; it was too hard to understand / hear and this created confusion; ALCON were not in net; and it was tied to a headset.

5.1.7.3 Suggested Improvements for Voice. The suggested improvements regarding Voice related to enhancing its usability and include: it needs on-screen "flag" to alert for new voice traffic; it should provide a multi-point capability; and make it so voice is continuous.

5.1.8 IWS. Due to limited availability during game, IWS was not used by many participants play although some indicated they felt IWS offered potential. Comments regarding the IWS

include: collaborative planning still requires a higher authority for final decisions in the MPP; participants should have been forced to use it; and participants felt that privacy leads to "stove-piping" of information. Participants' rankings of Voice ranged from 2.1 to 4.1 (see Table 2).

5.1.8.1 Benefits of IWS. IWS was viewed as useful for collaboration, as noted by comments such as: it provided a useful environment for collaboration and we need this for collaborative planning.

5.1.8.2 Limitations of IWS. The following comments provide an overview of what the participants viewed as limitations to IWS. Functionality issues were that IWS was not operationally focused, it was too "stove-piped" in that it provided limited simultaneous capability to be in more than one "room", and it offered no record capability. A reliability issue was that it was too sensitive to network loading and thus there was an inability to handle all the people. Usability issues include that IWS limited the user to one room or location at a time; it was frustrating to use without a battle rhythm or decision point laid out; it was much more complicated to share data than in email; and to review a new system, operators were required to return to home.

5.1.8.3 Suggested Improvements for IWS. Recommendations regarding improvements for IWS include that it needs: to be more flexible, in terms of allowing the user to particularly "hop" from room to room; to divide the server and provide a means to coordinate planning; strict business rules for user interaction; a nested collaboration capability to keep systems up longer; better graphic management; more areas accessible in the same room; the ability to locate a person w/o paging them; and incorporation of maps into IWS.

5.1.9 VTC. The VTC tool received the lowest rating on usefulness based on participant responses. While the ability to have eye contact, observe the speaker's body language, and hear the inflection in the speaker's voice appeared to be intuitively valued for building trust in the received message by some respondents, other factors appear to affect how the tool was rated. These other factors appear to include the participant's position in the organization, availability/ access to the tool, and prioritization of the value of this tool relative to other resources. It should be noted that technical difficulties including audio problems prevented participants from following the flow of information during some VTCs and this likely contributed to VTC receiving low ratings. Participants' rankings of VTC ranged from 1.7 to 2.4 (see Table 2), indicating a perception of low usefulness across respondents. However, preliminary analysis indicates that perceptions of utility for VTC may vary significantly based on user position in the organization.

5.1.9.1 Benefits of VTC. The only benefit listed by the participants was that eye contact and personal cues available with VTC helps build trust.

5.1.9.2 Limitations of VTC. Participants, across the board, indicated the technological difficulties encountered during the wargame with VTC detracted seriously from its use and appreciation of the potential features it offered. The following comments provide an overview of what the participants viewed as limitations to VTC: it delays progress; it is receive only; and while it was good for (high-level) decision makers, it added little for the operators.

6. View from USS CORONADO

The KW was the one tool that was designed specifically for the CINC who was located onboard the Third Fleet Flagship, USS CORONADO. In addition to feedback on the KW received from the participants at the Naval War College, participants on board USS CORONADO provided assessments and feedback regarding their reactions to the tools provided during the game. Some specific comments from the CINC regarding the KW display include those listed below. Most of these comments refer to additional information the CINC would like to have displayed on the KW in future iterations of the KW. Other comments reflect usability issues.

- What is the attrition of RED?
- What is the DEFCON for what area?
- Which strait is the Nimitz coming through? (Add PIM (projected intended movement) of carriers on KW)
- What other carriers and ATF (amphibious task force units) are due in the area? (Add schedule to KW)
- Why is the EFFECTS display RED in the summary but not in the detailed display?
- Need a better way to correlate the colors
- In scanning the KW, there isn't much that can be done about today; thus, the emphasis should be on tomorrow and the long-term picture
- Why are some RED today and YELLOW tomorrow?
- Prior to C-day did the CJTF employ Flexible Deterrent Options (FDOs)?
- Needs real-time assessment of Effects: unintended consequences, in particular, need quick fixes
- TAPS model is fantastic, but not timely

7. Summary of Analysis of Feedback on IT Tools

The responses to the IT Tools Questionnaire indicate the participants generally felt that all the tools offer potential and all have room for improvement. The majority of the comments indicate that users want tools that are more reliable, powerful, and developed to be more user-friendly and intuitive to use. In general, there was a learning curve involved before some tools could be fully utilized by the participants; as people develop greater familiarity and capability in using the tools, their impressions may become more favorable.

Some general types of feedback that were made in response to several of the tools and about the wargame in general are summarized below. Reliable, interactive systems with the range of attributes that were intended would represent a good first iteration of a collaborative system to support joint command and control decisionmaking. These tools need to be integrated so the decisionmaker does loose the picture by moving in and out of each area

7.1 Additional Capabilities Desired in Tools

Participants expressed the desire to have a better way to know Commander's Intent in terms of making Commander's Intent more understandable. A graphical representation of this information, depicting the overall battle picture embedded within the context of information critical to commander's Intent, would assist in users developing and maintaining good situation awareness. In addition, more powerful graphics, robust enough to present large volumes of data on one

display, is another capability the participants listed as important. Graphical presentations are viewed as a feature that would enhance the decisionmaker's ability to understand the situation. For example, including a graphic depiction of information during briefings, e.g., Order of Battle tables were stated to be too difficult to follow. More maps were also listed as an additional capability that would be useful, in particular maps with threat locations and labels of prominent features and regions.

8. Tools Desired in a Future Collaboration System

Participants rank ordered the eight tools included in the questionnaire, in terms of which tools they would like to have in a future collaboration tool. The overall rankings for the tools are shown in Figure 2. Participants varied considerably in their response to item # 5, that asked them to rate the tools — and the features — they would like to have in a future collaboration tool.

Rank ordering of the tools in terms of what features would you like to see in the design of a collaborative system? (1 = least useful; 8 – most useful)

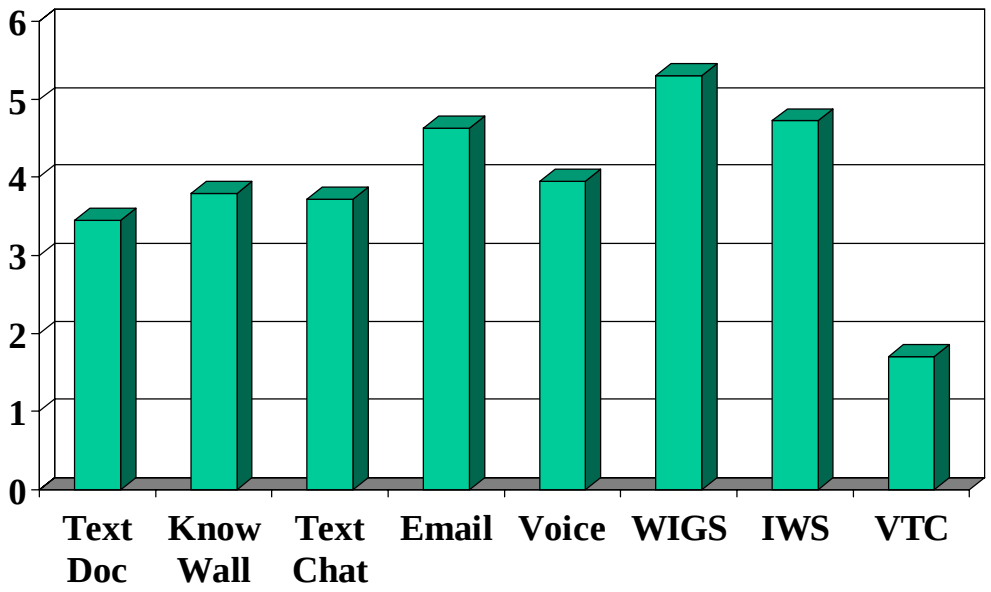

Figure 2. Mean ratings of tools desired in future collaboration system.

Table 3 breaks out participant ratings of the tools, in terms of the features they would like to see in the design of a future collaborative system, by the seven groups. WIGS received the highest ranking by three groups, was rated second highest by three groups, and third highest by one group. WIGS was rated as one of the top three tools by all seven groups. The general consensus was that WIGS provided a critical information source. However, remaining questions exist as to whether WIGS can be designed to be more user-friendly and whether its functionality can be improved (such as making it less cumbersome to use and less time intensive to use). WIGS was viewed by respondents as a very effective tool to facilitate easy, fast accessing and sharing of many information areas and as a vehicle to develop situation assessment.

Email was rated highest by three groups, was rated second highest by one group and third highest by one group. The features provided by email made it rank in the top three rankings by five of the seven groups. IWS was the highest ranked tool by one group and the second highest ranked tool by two groups. Text Chat was the next tool with the highest rankings, which was ranked second highest by one group, third highest by two groups and fourth highest by one group. Text Documents were ranked as the third most important tool by two groups. The Knowledge Wall was ranked the fourth highest tool by five of the seven groups.

Table 3. Rank Order of Desired Tools for Future Collaboration Tool by Group*

	CJTF	AFFOR	ARFOR	MAR-FOR	NAV-FOR	Reach-back	Others
Text Docs	4.0	4.0	4.7	6.0 3	3.7	6.0 3	4.2
Know Wall	4.8 4	4.0	4.8 4	4.7 4	4.5	5.8 4	5.3 4
Text Chat	4.5	6.7 2	4.9	4.7 4	5.2 3	4.3	5.4 3
Email	5.6 3	7.2 1	6.4 1	6.4 2	4.6	6.7 1	3.7
Voice	4.6	5.7 4	5.4 3	4.7 4	4.8 4	5.5	5.2
WIGS	6.5 1	6.5 3	5.5 2	6.5 1	6.1 2	6.4 2	6.4 1
IWS	6.0 2	4.7	4.7	4.6	6.5 1	5.7	6.2 2
VTC	2.5	2.0	4.2	2.8	1.7	3.7	2.2

*****Note: Numbers in the lower right-half corner of the cells indicate the ranking for each of the four highest-rated tools by all the groups.

9. Training

Based on participant feedback, additional, comprehensive training is needed on tools, individually, and then within the context of the organization and a scenario. Participants felt a need to develop a degree of proficiency in using the tools *prior* to actual game run so that there are not too many new things vying concurrently for their attention. Participants could be given time to engage in a "mini-scenario" where they can practice all of the behaviors they will need to perform in the actual game, but without the pressure of still trying to develop proficiency while responding to the mission requirements of the Global wargame scenario.

9.1 Additional Training Would be Beneficial

In order to develop a certain level of proficiency, in general, participants felt a need for enough time to perform (practice) the various actions in an interactive manner prior to engaging in the scenario, as opposed to just being shown how to do certain things. A tiered type of training may help participants develop greater proficiency. Tiered training would consist of: (1) an introductory lecture on the tools, the function for which each tool was developed and the associated business rules; (2) hands-on practice in using the tools individually; (3) in situ practice in a group setting where participants practice what they learned about the tools in an interactive setting.

9.2 Training Recommendations from Participants

Comments from participants were quite consistent in regard to the training provided for Global 2000. They recommend that the pre-game training should be mandatory for all players and that more time should be dedicated to training. A greater emphasis on "hands-on' practice for all tools was stated as being needed in addition to the lecture/briefing style of training.

10. Conclusions

The tools provided during Global 2000 had a major impact on the ability of the participants to access and share information, develop and maintain situation awareness, collaborate across functional areas and component cells, and coordinate both vertically and horizontally within the organization. A good deal was learned about the tools and ways to improve the tools for developing a future collaborative system. The following section summarizes the main lessons learned regarding the IT Tools used at Global 2000.

10.1 Lack of a Synthesized Picture

A major theme expressed by the participants throughout the organization was the need for synthesized presentations of information, both within the various tools used and across the tools. Instances where "information" from different tools was contradictory illustrate that there is a need to "manage" the information generated by the tools. (For example, in one situation when JFLEX (Joint Force Level Execution Program) was brought up the situation indicators showed all GREEN at the same time the KW had lots of situation buttons coded RED.) Many comments indicate that the participants really want a more synthesized picture of the current situation.

10.2 Lack of Bandwidth

A second major theme was the lack of sufficient bandwidth for all the tools to function as planned. This was a major impediment to accomplishing the game with the given organization structure and the "envisioned" roles and functions for the various participants.

10.3 Provide an Updated Picture of the Battle

An overarching theme across the comments made regarding all the tools was the need for a common picture of the situation. This suggested improvement applies both within some of the tools and across the tools.

10.4 Need Business Rules

Business rules were requested to provide a standard protocol for using the tools and for interpreting the information presented. General business rules are needed to provide guidance on conducting operations in the new operational milieu envisioned in a network-centric environment. System specific business rules are needed regarding when and where to post information, how to update and authenticate information, and to increase efficiency by reducing the need for decision-makers to search through tools and data to extract the needed information. Making the tools easier to use will also reduce the cognitive workload for the user, thus freeing up finite cognitive resources for the decisions that require the human decision maker and thus increasing "speed of command."

10.5 Develop Tools that are More Intuitive to Use

Many systems appear to require an interface that is more intuitive for the user, who is often required to make critical decisions under time-compressed and ambiguous conditions. These stressful decision-making environments require tools that are truly supportive of the user, so the user doesn't have to "fight" the tools, in addition to fighting the actual battle. For example, an intuitive browsing capability would enable users to access more information, more rapidly. A tool that is designed to be intuitive to use will reduce the training time required and will increase the amount of support it supplies to the decision-maker.

10.6 Need Additional Training

There were observations throughout the cells of instances where players did not know how to use the tools to sufficiently to realize the inherent capabilities of the tools. There were also instances where players did not know where to go to get information from the "system."

11. DISCUSSION

11.1 IT Tools and Network Centric Warfare

IT Tools are only one element of a complicated set of new processes, ways of organizing, and a netted infrastructure that will fundamentally alter how warfare and military operations are conducted in the future. As the concepts embodied in NCO continue to develop, these concepts will be enabled by a variety of decision support, analysis, troubleshooting, and adaptation tools. It will be important to develop these concepts — and the tools that will support the concepts — in a coordinated way that will achieve the synergy that is envisioned. The criticality of integrating all these new elements to ensure a good match between the processes to be employed, the new ways people will be organized, and technology is exacerbated. The transformation of information to knowledge further increases reliance on the human element as the critical element in the system of systems in terms of the way decision superiority can result from the cognitive processes enabled by technology. A fundamental element of success in future military operations may be the realization that the "network" in network centric warfare is the network of people engaged in mutually supporting activities to achieve a common set of goals using an integrated collaborative set of tools.

11.2 Principles of Collaborative Command and Control

Command and control principles are fairly well established (such as centralized planning and decentralized execution, feedback loops, unity of command, unity of effort, etc.), yet the evolution of information sharing and collaborative planning technologies have potentially deep implications for command and control. Network-Centric Operations may introduce entirely new principles or require the modification of old principles. Without articulation of new, clear principles, it is difficult to proceed with the design of processes, codification of business rules and the other steps necessary to provide a modern command and control system. Moreover, military requirements are arguably different from commercial information requirements and the systems that are produced to support those requirements. Differences include dynamic reconfiguration, survivability/ redundancy, and adaptability, at the least. Collaboration must be conducted within these requirements and the essentials of the military environment.

12. RECOMMENDATIONS

Based on the analysis presented in this paper, we suggest a dialogue on the nature of the principles of Collaborative Command and Control. These principles would serve to support decision superiority in a network-centric environment. A “strawman” set of draft principles should provide the foundation for the first step — which is to stimulate discussion. The strawman set of principles would also be useful for identifying issues for experimentation, formulation of new concepts, and general guidance for system designers.

An alternative approach would be to identify groups of existing principles of military C2 and prepare discussion papers on whether they may be impacted by the advances in information technology. Participants would indicate the degree and direction of modification. Then, an initial document could be prepared on the modified principles. A second alternative approach would be to start from a fresh viewpoint regarding the requirements emerging from the need to collaborate that have been identified, largely from commercial practice. Then the additional, specific requirements levied by the needs of a military environment and the possible adjustments that would be needed to support information sharing and collaboration would be specified. This information regarding specific military needs would be integrated to provide a draft of principles for the design and use of information technologies to support Collaborative Command and control.

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